AF/2862

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IN THE UNITED STATES PATENT AND TRADEMARK OFFICE
BEFORE THE BOARD OF PATENT APPEALS AND INTERFERENCES

APPLICANTS:	Wolfgang RENZ et al.	CONFIRMATION NO.: 2414	
SERIAL NO.:	09/540,113	GROUP ART UNIT: 2862	
FILED:	March 31, 2000	EXAMINER: T. Fetzner	
TITLE:	**"MAGNETIC RESONANCE ANTENNA"**		

#10
Appeal Brief Attached

Assistant Commissioner for Patents,

Washington, D.C. 20231

APPELLANTS' MAIN BRIEF ON APPEAL

S I R:

In accordance with the provisions of 37 C.F.R. §1.192, Appellants herewith submit their Main Brief in support of the Appeal of the above-referenced application.

Real Party In Interest:

The real party in interest is the Assignee of the application, Siemens Aktiengesellschaft, a German corporation.

Related Appeals And Interferences:

There are no related Appeals and no related interferences.

Status Of Claims:

Claims 1-13 are the subject of this Appeal, and constitute all pending of the application.

Status Of Amendments:

This Brief is accompanied by an Amendment filed under 37 C.F.R. §1.116(b) and therefore at this time no action on this Amendment has been taken. The

Amendment revises the language only in claim 1. The claims appended hereto include a copy of claim 1 in the form it will have if the Amendment is not entered, as well as a copy of claim 1 in the form it will have if the Amendment is entered.

Summary Of The Invention:

The subject matter of the claims on appeal is a magnetic resonance antenna for use in magnetic resonance imaging systems.

Figure 1 shows the basic shape of an inventive magnetic resonance antenna. It has at least five (eight according to Figure 1) antenna elements 1. (p. 4, l. 4-6) The antenna elements 1 extend radially from an inner element bar beginning 3 to an outer element end with respect to a center axis 2. (p. 4, l. 6-7) According to Figure 1, the element beginnings 3 are connected to one another in an electrically conducting manner via an inner connecting element 5, and the element ends 4 are connected to one another in an electrically conducting manner via an outer connecting element 6. (p. 4, l. 8-11) According to Figure 1, both connecting elements 5, 6 are fashioned in a ring-shaped manner. (p. 4, l. 11-12) Therefore, the antenna elements 1 not only are magnetically coupled with one another but also are electrically coupled. (p. 4, l. 13-14) The magnetic resonance antenna exhibits a cyclic symmetry from antenna element 1 to antenna element 1. (p. 4, l. 14-16)

The magnetic resonance antenna has two connections 7, which, offset by 90^0, are arranged at the outer connecting element 6. (p. 7, l. 17-18) At these two connections 7, two currents that are phase-shifted by 90^0 can be alternatively coupled in or coupled out with a magnetic resonance frequency f. (p. 7, l. 18-20) As a result, a circularly polarized magnetic field can be alternatively emitted or received with the magnetic resonance antenna according to Figure 1. (p. 4, l. 20-22) The

magnetic resonance frequency usually lies between 8 MHZ and 100 MHZ. (p. 4, l. 22-23) The currents and magnetic fields that flow at a specific point in time are indicated in Figure 1 by means of the normal symbols. (p. 4, l. 23-25)

According to Figure 1, capacitors 8 are arranged in the outer connecting element 6. Alternatively, the capacitors 8 could be arranged in the inner connecting element 5 or in the antenna elements 1. (p. 4, l, 26-28)

Figures 2 through 5 show modifications of the basic fashioning according to Figure 1. Identical elements are thereby provided with identical reference numbers. The capacitors 8 contained in the antenna elements 1 and/or in the connecting elements 5, 6 are not shown in the Figures 2 through 5 for simplification. (p. 5, l. 1-5)

According to Figures 2 and 3, the element ends 4 are connected to one another in an electrically conducting manner via the outer connecting element 6. (p. 5, l. 6-8) In contrast thereto, the element beginnings 3 are directly connected to one another in an electrically conducting manner according to Figure 2 and, according to Figure 3, are grounded. (p. 5, l. 8-10) Further, in the embodiment of Figure 2, the antenna elements 1 are split toward the outside, i.e. they respectively have two element ends 4. (p. 5, l. 10-12) In the embodiment of Figure 4, the element beginnings 3 are connected to one another in an electrically conducting manner via the inner connecting element 5 and the element ends 4 are grounded. (p. 5, l. 12-15)

In the embodiment according to Figure 5, the antenna elements 1 are only magnetically coupled with one another. According to Figure 5, the element beginnings 3 and the element ends 4 are grounded. (p. 5, l. 16-18)

Figure 6 shows the embodiment of the magnetic resonance antenna according to Figure 4 in profile from the side. (p. 5, l. 19-20) The magnetic resonance antenna is planarly constructed. It is also possible (as explain d in the following in connection with Figure 7) that the element beginnings 3 define an element beginning plane 9 and that the element ends 4 define an element end plane 10, the element beginning plane 9 and the element end plane 10 extending parallel to another, and being offset from one another. (p. 5, l. 20-25)

Figure 7 shows the basic fashioning of the magnetic resonance antenna according to Figure 1 from the side. (p. 5, l. 21-22) According to Figure 7, the antenna element 1 each proceed along respective lines. The extrapolation of the line direction intersects the center axis 2 in a common intersecting point 11. The intersecting point 11 is situated in a grounding plate 12, which extends parallel to the element beginning plane 9 and to the element end plane 10. The slope of the antenna elements 1 relative to the grounding plate 12 should not exceed 45^0. Otherwise, the slope can be selected as required. (p. 5, l. 22 - p. 6, l. 3)

The number of antenna elements 1 can be selected as required as long as it is equal to or exceeds five. It is particularly beneficial, however, when the number can be divided by four, namely 8, 12, 16 etc.. Then, the coupling-in and coupling-out of two currents, which are phase-shifted by 90^0, is especially simple for generating or scanning a circularly polarized magnetic field. (p. 6, l. 7-12)

The inventive magnetic resonance antenna can be utilized in magnetic resonance systems with a vertical basic field in order to generate or receive a high-frequency magnetic field that is transverse relative to the vertical basic field. It is particularly advantageous that crossing (overlapping) antenna element do not occur

in the basic design and thus will not come into contact with one another, so that special measures do not have to be undertaken to isolate the elements from one another. (p. 6, l. 13-19)

Issues:

The issue on appeal is whether the subject matter of claims 1-13 is anticipated under 35 U.S.C. §102(b) by United States Patent No. 4,620,155 (Edelstein).

Grouping Of Claims:

The patentability of dependent claims 2, 3 and 8-13 is not argued separately from independent claim 1 from which those claims depend.

The patentability of each of claims 4, 5, 6 and 7 does not stand or fall together with the patentability of claim 1, and respective, separate arguments in support of the patentability of each of claims 4, 5, and 7 are set forth below.

Argument:

Independent claim 1 on appeal sets forth an antenna for use in a nuclear magnetic resonance apparatus having a plurality of antenna elements, and states that each of those antenna elements has an element beginning and an element end. The antenna elements are stated in claim 1 to be disposed radially relative to a center axis, so as to proceed outwardly from the respective element beginnings to the respective element ends. The antenna elements are also stated to exhibit cyclical symmetry from antenna element to antenna element, and the antenna elements are at least magnetically coupled with each other. Claim 1 also requires that the plurality be at least five.

Appellants submit that a person of ordinary skill in the art, applying not only the standard dictionary meaning of "radial, but also the knowledge and understanding of those skilled in the art of antenna d sign as to the meaning of a "radial" antenna element, would understand claim 1 to describe and claim antenna elements that are arranged in the manner of the spokes of a wheel. Such a person of ordinary skill in the art also would understand claim 1 to be describing and claiming antenna elements which are individually identifiable, i.e. discrete, physical elements.

This is supported by the attached excerpt from Webster's Ninth New Collegiate Dictionary (1983), page 970 wherein the word "radial" is variously defined as "arranged" or having parts arranged like rays" (giving the example of the form of a starfish), and "relating to, placed like, or moving along a radius, and "characterized by divergence from a center."

The Edelstein reference discloses a magnetic resonance antenna having two co-planar coils, each formed by a plurality of segments, connected by tuning elements. In the embodiment shown in Figure 3 of the Edelstein reference, the outer coil has an octagon shape, and the Examiner has interpreted the segmental elements 23a through 23f, forming this octagon, as corresponding to the claimed "plurality of antenna elements." The Examiner interprets the Edelstein reference as teaching that each of these "antenna elements" has an "element beginning," which the Examiner considers to be the radial inner end point across (i.e. opposite) the location where the respective components 29a through 29h connect to the segments 23a through 23h. The Examiner is interpreting the "antenna elements" of the Edelstein reference as each having an "element end" corresponding to the "element

end" of claim 1, as being the radial outer end point where components 29a through 29h connect to the segments 23a through 23h.

In other words, at each of the angles of the octagon formed by the segments 23a through 23h, the Examiner has drawn an imaginary line proceeding from the inner angle to the outer angle and is interpreting one end of that line as an inner element end and the opposite end of that line as being an outer element end.

Appellants respectfully submit that such an arbitrary characterization of the structure shown in the Edelstein reference has occurred to the Examiner only in an effort to "force" claim 1 of the present application to read on Figure 3 of the Edelstein reference. According to the aforementioned dictionary definition of "radial" and the understanding of those of ordinary skill in the art as to the meaning and structure of a "radial antenna element," Appellants respectfully submit the Examiner's interpretation of the Edelstein reference is not justified. Moreover, this interpretation is contrary to the language of the Edelstein reference itself, which refers to the "ends" of the respective segments 23a through 23h as being where coupling elements (capacitors) 27a through 27g are connected (Edelstein, column 4, lines 33-37). This is consistent with the interpretation which a person of ordinary skill in the art would give to the Edelstein reference, without first reading Appellants' disclosure. A person of ordinary skill in the art looking at Figure 3 would automatically characterize the portions of the segments 23a through 23h which are adjacent the respective gaps to be the "end" of those segments, rather than some arbitrary location within each segment. This is particularly true in view of the strip-like nature of the segments 23a through 23h. For any strip-like structure, it would be common

to refer to the opposite terminations of the strip as being the "ends" of that strip, rather than some arbitrary point within the strip itself.

Appellants recognize that an Examiner is required to give every term in a patent claim its broadest reasonable interpretation, however, an interpretation is not "reasonable" if it is at odds with common usage and/or at odds with the description in the reference itself, as is the Examiner's interpretation of the Edelstein reference.

For an anticipation rejection under 35 U.S.C. §102(b), the explicit language of the statute requires the invention to be "patented or described in a printed publication...". The claims of the Edelstein reference clearly do not "patent" the subject matter of claim 1 on appeal, since completely different language is used in Edelstein claims compared to the language of claim 1. Therefore, Appellants assume that the Examiner is taking the position that the Edelstein reference "describes" the subject matter of claim 1 and the other claims on appeal. The Federal Circuit, however, has provided rather strict guidelines for use in determining when an allegedly anticipating reference "describes" the invention against which it is being applied. In *In Re Paulsen*, 31 U.S.P.Q. 2nd 1671, 1673 (Fed. Cir. 1994), the Federal Circuit stated

> [T] the reference must be enabling and describe the Appellants' claimed invention sufficiently to have placed it in possession of a person of ordinary skill in the field of the invention.

Further, in *Chester v. Miller*, 15 U.S.P.Q. 2d 1333, 1336 n.2 (Fed. Cir. 1990), the Federal Circuit stated:

> To be prior art under section 102(b) the reference must put the anticipating subject matter at issue into the possession of the public through an enabling disclosure.

In this regard, the Federal Circuit has emphasized the difference between "mere" disclosure and "enabling" disclosure in *Paper List Accounting Inc. v. Bay Area Rapid Transit System,* 231 U.S.P.Q. 649, 653 (Fed. Cir. 1986):

> [E]ven if the claimed invention is disclosed in a printed publication, that disclosure will not suffice as prior art if it was not enabling. ...The basis for this rule is found in the description requirement of §102(b).

Clearly, the Edelstein reference does not put the subject matter of claim 1 on appeal in the possession of the public. It is only by an expost facto reading of the Edelstein disclosure, having claim 1 on appeal before her, that the Examiner has been able to take the position that the Edelstein reference allegedly anticipates claim 1. The last-cited decision of the Federal Circuit makes clear that even if, with the benefit of hindsight, a "disclosure" of the invention in question can be found by some sort of interpretation of a reference, that reference still will not qualify as an anticipating reference unless that disclosure is "enabling."

Appellants submit that a further way to test whether the Edelstein disclosure is, in fact, an "enabling" disclosure for the subject matter of claim 1 is to ask whether, if claim 1 on appeal had been presented as a claim during prosecution of the application which issued as the Edelstein patent, the Examiner would have believed that claim 1 on appeal was adequately disclosed in the Edelstein specification under the requirements of 35 U.S.C. §112, first paragraph. Appellants submit that if claim 1 on Appeal had been presented during the prosecution of the Edelstein application, it would have been rejected, at least for a lack of enablement, under 35 U.S.C. §112, first paragraph, and would not have been permitted to remain in the application. This is particularly true because, in order to accept the Examiner's interpretation of the

Edelstein's teachings, one must adopt a definition of the "ends" of the segments which is different from the definition given in the Edelstein disclosure itself.

The Edelstein reference therefore does not disclose all of the elements of claim 1 as arranged and operating in that claim, and does not anticipate claim 1 nor any of claims 2, 3 or 8-13 depending therefrom.

Dependent claim 4 states that the respective element beginnings are electrically connected to each other via a ring-shaped connecting element. Even if the Examiner's interpretation of the Edelstein reference is accepted, it is clear that under this interpretation the "element beginnings" are not electrically connected to each other via any sort of connecting element, much less a ring-shaped connecting element. As noted above, the elements 23a through 23h are separated from each other by respective gaps, and each of those gaps is bridged by an electrical circuit element such as a capacitor, a combination of a capacitor and an inductor, or diodes connected with opposite polarities. Therefore, there is no "connecting element" which connects the element beginnings in the Edelstein reference. If the interior angles of each segment 23a through 23h, given the Examiner's interpretation, are considered to be "element beginnings," then those element beginnings are electrically connected to each other by the remainder of the segment containing the "element beginning" and some type of electrical component. Such a combination of the segments themselves and intervening circuit components is not a "connecting element" as set forth in claim 4. Moreover, even if such a combination were (unjustifiably) considered to be a "connecting element" it would not be a "ring-shaped connecting element" as required in claim 4.

The same arguments apply with respect to claim 5, which states that the respective element ends are electrically connected to each other via a ring-shaped connecting element. The same arguments discussed above in connection with the inner angles of the segments 23a through 23h apply to the outer angles of those segments, which the Examiner has characterized as "element ends".

Claim 6 states that the element beginnings are electrically connected to each other via a first ring-shaped connecting element, and the element ends are respectively connected to each other via a second ring-shaped connecting element. For the same reasons discussed above in connection with claims 4 and 5, no connecting elements are present at all, and certainly no ring-shaped connecting elements are present, and certainly there is no structure identifiable in the Edelstein reference which could conform to a first ring-shaped connecting element and a second ring-shaped connecting element, as required in claim 6.

Claim 7 states that each of the antenna elements has two branching ends, and is directed to the embodiment shown in Figure 2. In supporting the anticipation rejection of claim 7, the Examiner merely cited Figure 3 of the Edelstein reference as showing (or suggesting) that "each of said antenna elements has two branching element ends." The Examiner did not identify any structure in Figure 3 which would allegedly correspond to "two branching element ends."

The above arguments apply to the language of claims 1-13 even if the Amendment submitted herewith is not entered. In that Amendment, however, additional language is added in claim 1 stating that a radially directed current flow exists in each antenna element between the element end thereof and the element beginning thereof. This is indicated in Figure 1 by the arrows proceeding inwardly or

outwardly along the antenna elements 7. The word "between" as used in this Amendment is not intended to indicate that the current has a particular direction radially inwardly or radially outwardly, but only that it proceed between the opposite ends of each antenna element, in one or the other direction.

Clearly, no such radial current flow exists in the Edelstein reference, given the arbitrary attribution of the "element beginning" and "element end" in the respective segments 23a and 23h. As noted above, current flow in the Edelstein reference does, in fact, proceed between the "ends" of those segments, but those ends are defined as the locations adjacent the various gaps, and therefore this current flow is a circumferential flow, rather than a radial flow. This is also clear from the fact the excitation signal is applied to the coil 21 via surface coil ends 21a and 21b, via a connector 23c. This could not occur if current flow were radial. Moreover, the presence of the diodes 28a and 28b would be meaningless if current flow were radial since those diodes have no capability of effecting a radial current flow whatsoever.

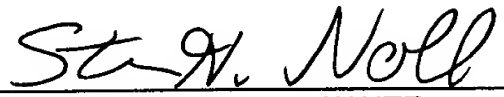
If the Amendment accompanying this Brief is entered, therefore, this provides yet a further argument in support of patentability of claim 1 and the claims depending therefrom. As noted above, however, Appellants believe that claim 1 and the claims depending therefrom are patentable over the Edelstein reference even if this Amendment is not entered.

Conclusion:

.For the above reasons, Appellants respectfully submit the Examiner is in error in law and in fact in rejecting claims 1-13 as being anticipated by the Edelstein reference. Reversal of that rejection and allowance of all claims of the application are therefore respectfully requested.

This Brief is accompanied by a check for the requisite fee in the amount of $320.00.

Submitted by,



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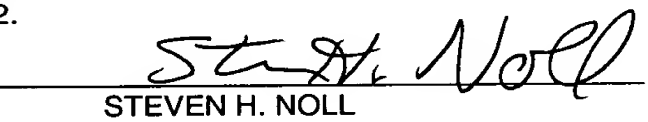
I hereby certify that an original and two copies of this correspondence are being deposited with the United States Postal Service as First Class mail in an envelope addressed to: Assistant Commissioner for Patents, Washington, D.C. 20231 on August 30, 2002.



STEVEN H. NOLL

APPENDIX "A"

1. **(Version if Amendment Accompanying Brief is not entered)** A nuclear magnetic resonance antenna comprising:

a plurality of antenna elements, each antenna having an element beginning and an element end;

said antenna elements being disposed radially relative to a center axis so as to proceed outwardly from the respective element beginnings to the respective element ends and exhibiting cyclical symmetry from antenna element to antenna element;

said antenna elements being at least magnetically coupled with each other; and

said plurality being at least five.

1. **(Version if Amendment Accompanying Brief is entered)**1. (Amended) A nuclear magnetic resonance antenna comprising:

a plurality of antenna elements, each antenna having an element beginning and an element end;

said antenna elements being disposed radially relative to a center axis so as to proceed outwardly from the respective element beginnings to the respective element ends to allow a radially directed current flow in each antenna element between the element end thereof and the element beginning thereof, and exhibiting cyclical symmetry from antenna element to antenna element;

said antenna elements being at least magnetically coupled with each other; and

said plurality being at least five.

2. A nuclear magnetic resonance antenna as claimed in claim 1, wherein the respective element beginnings and the respective element ends are connected to ground.

3. A nuclear magnetic resonance antenna as claimed in claim 1 wherein said antenna elements are electrically coupled to each other.

4. A nuclear magnetic resonance antenna as claimed in claim 3 wherein the respective element beginnings are electrically connected to each other via a ring-shaped connecting element.

5. A nuclear magnetic resonance antenna as claimed in claim 3 wherein the respective element ends are electrically connected to each other via a ring-shaped connecting element.

6. A nuclear magnetic resonance antenna as claimed in claim 3 wherein the respective element beginnings are electrically connected to each other via a first ring-shaped connecting element and wherein the respective element ends are electrically connected to each other via a second ring-shaped connecting element.

7. A nuclear magnetic resonance antenna as claimed in claim 1, wherein each of said antenna elements has two branching element ends.

8. A nuclear magnetic resonance antenna as claimed in claim 1 wherein the respective element beginnings define an element beginning plane and wherein the respective element ends defines an element end plane, and wherein said element beginning plane and said element end plane are parallel to and spaced from each other.

9. A nuclear magnetic resonance antenna as claimed in claim 8 wherein the respective antenna elements are linear.

10. A nuclear magnetic resonance antenna as claimed in claim 8 wherein the respective antenna elements define respective line directions, said line directions intersecting said center axis at a common point.

11. A nuclear magnetic resonance antenna as claimed in claim 10 further comprising a grounding plate disposed parallel to said element beginning plane and said element end plane, and said common point being disposed in said grounding plate.

12. A nuclear magnetic resonance antenna as claimed in claim 8 further comprising a grounding plate disposed parallel to said element beginning plane and said element end plane.

13. A nuclear magnetic resonance antenna as claimed in claim 1 wherein said plurality is divisible for four.

A
B

WEBSTER'S Ninth New Collegiate Dictionary

A GENUINE MERRIAM-WEBSTER

The name *Webster* alone is no guarantee of excellence. It is used by a number of publishers and may serve mainly to mislead an unwary buyer.

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rotary motion to linear motion or vice versa (as in an automobile steering mechanism or microscope drawtube) b : a notched bar used as a ratchet to engage with a pawl, click, or detent 7 : a pair of antlers 8 : a triangular frame used to set up the balls in a pool game; *also* : the balls as set up — **rack-ful** \-,fu̇l\ *n* — **on the rack** : under great mental or emotional stress

⁴rack *vt* (15c) 1 : to torture on the rack 2 : to cause to suffer torture, pain, or anguish 3 a : to stretch or strain violently ⟨~*ed* his brains⟩ b : to raise (rents) oppressively c : to harass or oppress with high rents or extortions 4 : to work or treat (material) on a rack 5 : to work by a rack and pinion or worm so as to extend or contract ⟨~ a camera⟩ 6 : to seize (as parallel ropes of a tackle) together 7 : to place (as pool balls) in a rack ~ *vi* : to become forced out of shape or out of plumb *syn* see AFFLICT — **rack-er** *n* — **rack-ing-ly** \'rak-iŋ-lē\ *adv*

⁵rack *vt* [ME *rakken*, fr. OProv *arraca*] (15c) : to draw off (as wine) from the lees

⁶rack *vi* [prob. alter. of ¹*rock*] *of a horse* (1530) : to go at a rack

⁷rack *n* (1580) : either of two gaits of a horse: a : PACE 4b b : a fast showy 4-beat gait

⁸rack *n* [perh. fr. ³*rack*] (1570) 1 : the neck and spine of a forequarter of veal, pork, or esp. mutton 2 : the rib section of a foresaddle of lamb used for chops or as a roast — see LAMB illustration

⁹rack *n* [alter. of *wrack*] (1599) : DESTRUCTION ⟨~ and ruin⟩

¹rack-et *also* **rac-quet** \'rak-ət\ *n* [MF *raquette*, fr. Ar *rāḥah* palm of the hand] (1500) 1 : a lightweight implement that consists of a netting (as of nylon) stretched in a usu. oval open frame with a handle attached and that is used for striking the ball or shuttlecock in various games (as tennis, racquets, or badminton) 2 *usu* **racquets** *pl but sing in constr* : a game for two or four players with ball and racket on a 4-walled court

²racket *n* [origin unknown] (1565) 1 : confused clattering noise : CLAMOR 2 a : social whirl or excitement b : the strain of exciting or trying experiences 3 a : a fraudulent scheme, enterprise, or activity b : a usu. illegitimate enterprise made workable by bribery or intimidation c : an easy and lucrative means of livelihood d *slang* : OCCUPATION, BUSINESS

³racket *vi* (1762) 1 : to engage in active social life 2 : to move with or make a racket

¹rack-e-teer \,rak-ə-'ti(ə)r\ *n* (1928) : one who obtains money by an illegal enterprise usu. involving intimidation

²racketeer *vi* (1928) : to carry on a racket ~ *vt* : to practice extortion on

rack-ety \'rak-ət-ē\ *adj* (1773) 1 : NOISY 2 : FLASHY, ROWDY 3 : RICKETY

rack-le \'rak-əl\ *adj* [ME *rakel*] *chiefly Scot* (14c) : IMPETUOUS, HEADSTRONG

rack railway *n* (1884) : a railway having between its rails a rack that meshes with a gear wheel or pinion of the locomotive for traction on steep grades

rack–rent *vt* (1748) : to subject to rack rent

rack rent *n* [⁴*rack*] (1607) 1 : an excessive or unreasonably high rent 2 *Brit* : the highest rent that can be earned on a property

rack–rent-er \'rak-'rent-ər\ *n* (1680) : one that pays or exacts rack rent

rack up *vt* (1949) : ACCUMULATE, GAIN ⟨*racked up* 30 points in the first half⟩

ra-clette \ra-'klet, rä-\ *n* [F, fr. *racler* to scrape] (ca. 1949) : a Swiss dish consisting of cheese melted over a fire and then scraped onto bread or boiled potatoes; *also* : the cheese used in this dish

ra-con \'rā-,kän\ *n* [*radar beacon*] (1945) : RADAR BEACON

ra-con-teur \,rak-,än-'tər, -ən-\ *n* [F, fr. MF, fr. *raconter* to tell, fr. OF, fr. *re-* + *aconter*, *acompter* to tell, count — more at ACCOUNT] (1828) : one who excels in telling anecdotes

ra-coon *var of* RACCOON

rac-quet-ball \'rak-ət-,bȯl\ *n* (1968) : a game similar to handball that is played on a 4-walled court with a short-handled racket and a larger ball

¹racy \'rā-sē\ *adj* **rac-i-er; -est** [³*race*] (1650) 1 : having the distinctive quality of something in its original or most characteristic form 2 a : full of zest or vigor b : having a strongly marked quality : PIQUANT ⟨a ~ flavor⟩ c : RISQUÉ, SUGGESTIVE *syn* see PUNGENT — **rac-i-ly** \'rā-sə-lē\ *adv* — **rac-i-ness** \-sē-nəs\ *n*

²racy *adj* **rac-i-er; -est** [¹*race*] (1841) : having a body fitted for racing : long-bodied and lean

rad \'rad\ *n* [radiation absorbed *dose*] (1918) : a unit of absorbed dose of ionizing radiation equal to an energy of 100 ergs per gram of irradiated material

ra-dar \'rā-,där\ *n, often attrib* [*ra*dio *de*tecting *a*nd *r*anging] (ca. 1941) : a radio device or system for locating an object by means of ultrahigh-frequency radio waves reflected from the object and received, observed, and analyzed by the receiving part of the device in such a way that characteristics (as distance and direction) of the object may be determined

radar astronomy *n* (1959) : astronomy dealing with investigations of celestial bodies in the solar system by analyzing radar waves directed toward and reflected from the object being studied

radar beacon *n* (1945) : a radar transmitter that upon receiving a radar signal emits a signal which reinforces the normal reflected signal or which introduces a code into the reflected signal esp. for identification purposes

ra-dar-scope \'rā-,där-,skōp\ *n* [*radar* + *oscilloscope*] (1945) : the oscilloscope or screen serving as the visual indicator in a radar receiver

radar telescope *n* (1953) : a radar transmitter-receiver with an antenna for use in radar astronomy

¹rad-dle \'rad-ᵊl\ *n* [prob. alter. of *ruddle*] (1523) : RED OCHER

²raddle *vt* **rad-dled; rad-dling** \'rad-liŋ, -ᵊl-iŋ\ (1631) : to mark or paint with raddle

³raddle *vt* **rad-dled; rad-dling** \'rad-liŋ, -ᵊl-iŋ\ [E dial. *raddle* (supple stick interwoven with others as in making a fence)] (1671) : to twist together : INTERWEAVE

rad-dled \'rad-ᵊld\ *adj* [origin unknown] (1694) 1 : being in a state of confusion : lacking composure 2 : BROKEN-DOWN, WORN

radi- *or* **radio-** *comb form* [F, fr. L *radius* ray] 1 a : radial : radially ⟨*radio*symmetrical⟩ b : radial and ⟨*radio*bicipital⟩ 2 a : radiant energy : radiation ⟨*radio*active⟩ ⟨*radio*opaque⟩ b : radioactive ⟨*radio*element⟩ c : radium : X rays ⟨*radio*therapy⟩ d : radioactive isotopes esp. as produced artificially ⟨*radio*carbon⟩ e : radio ⟨*radio*telegraphy⟩

¹ra-di-al \'rād-ē-əl\ *adj* [ML *radialis*, fr. L *radius* ray] (1570) 1 : arranged or having parts arranged like rays ⟨the ~ form of a starfish⟩ 2 a : relating to, placed like, or moving along a radius b : characterized by divergence from a center 3 : of, relating to, or adjacent to a bodily radius ⟨the thumb is on the ~ aspect of the hand⟩ 4 : developing uniformly around a central axis ⟨~ cleavage of an egg⟩ — **ra-di-al-ly** \-ē-ə-lē\ *adv*

²radial *n* (1872) 1 a : a radial part b : RAY 2 : a body part (as an artery) lying near or following the course of the radius 3 : a pneumatic tire in which the ply cords that extend to the beads are laid at approximately 90 degrees to the center line of the tread — called also *radial-ply tire, radial tire*

ra-di-a-le \,rād-ē-'al-(,)ē, -'äl-, -'āl-\ *n, pl* **-lia** \-ē-ə\ [NL, fr. ML, neut. of *radialis*] (1888) : a bone or cartilage of the carpus that articulates with the radius; *specif* : the navicular in man

radial engine *n* (ca. 1910) : a usu. internal-combustion engine with cylinders arranged radially like the spokes of a wheel

radial symmetry *n* (1890) : the condition of having similar parts regularly arranged around a central axis — **radially symmetrical** *adj*

ra-di-an \'rād-ē-ən\ *n* (1879) : a unit of plane angular measurement that is equal to the angle at the center of a circle subtended by an arc equal in length to the radius

ra-di-ance \'rād-ē-ən(t)s\ *n* (1601) 1 : the quality or state of being radiant 2 : a deep pink 3 : the flux density of radiant energy per unit solid angle and per unit projected area of radiating surface

ra-di-an-cy \-ən-sē\ *n* (1646) : RADIANCE

¹ra-di-ant \'rād-ē-ənt\ *adj* (15c) 1 a : radiating rays or reflecting beams of light b : vividly bright and shining : GLOWING 2 : marked by or expressive of love, confidence, or happiness ⟨a ~ smile⟩ 3 a : emitted or transmitted by radiation b : emitting or relating to radiant heat 4 : of, relating to, or exhibiting biological radiation *syn* see BRIGHT — **ra-di-ant-ly** *adv*

²radiant *n* (1727) : something that radiates: as a : a point in the heavens at which the visible parallel paths of meteors appear to meet when traced backward b : a point or object from which light emanates c : the part of a gas or electric heater that becomes incandescent

radiant energy *n* (ca. 1890) : energy traveling as a wave motion; *specif* : the energy of electromagnetic waves

radiant flux *n* (ca. 1925) : the rate of emission or transmission of radiant energy

radiant heat *n* (1794) : heat transmitted by radiation as contrasted with that transmitted by conduction or convection

radiant heating *n* (1937) : PANEL HEATING

¹ra-di-ate \'rād-ē-,āt\ *vb* **-at-ed; -at-ing** [L *radiatus*, pp. of *radiare*, fr. *radius* ray] *vi* (1619) 1 : to proceed in a direct line from or toward a center 2 : to send out rays : shine brightly 3 a : to issue in or as if in rays b : to evolve by radiation ~ *vt* 1 : to send out in or as if in rays 2 : IRRADIATE, ILLUMINATE 3 : to spread abroad or around as if from a center

²ra-di-ate \'rād-ē-ət, -ē-,āt\ *adj* (1668) : having rays or radial parts: as a : having ray flowers b : characterized by radial symmetry : radially symmetrical — **ra-di-ate-ly** *adv*

ra-di-a-tion \,rād-ē-'ā-shən\ *n* (1570) 1 a : something that is radiated b : energy radiated in the form of waves or particles 2 a : the action or process of radiating b (1) : the process of emitting radiant energy in the form of waves or particles (2) : the combined processes of emission, transmission, and absorption of radiant energy 3 : radial arrangement 4 : biological evolution in a group of organisms that is characterized by spreading into different environments and by divergence of structure 5 : RADIATOR — **ra-di-a-tion-al** \-shnəl, -shən-ᵊl\ *adj* — **ra-di-a-tion-less** \-shən-ləs\ *adj* — **ra-di-a-tive** \'rād-ē-,āt-iv\ *adj*

radiation sickness *n* (1924) : sickness that results from exposure to radiation and is commonly marked by fatigue, nausea, vomiting, loss of teeth and hair, and in more severe cases by damage to blood-forming tissue with decrease in red and white blood cells and with bleeding

ra-di-a-tor \'rād-ē-,āt-ər\ *n* (1836) : one that radiates: as a : any of various devices (as a nest of pipes or tubes) for transferring heat from a fluid within to an area or object outside b : a transmitting antenna

¹rad-i-cal \'rad-i-kəl\ *adj* [ME, fr. LL *radicalis*, fr. L *radic-*, *radix* root — more at ROOT] (14c) 1 : of, relating to, or proceeding from a root: as a (1) : of or growing from the root of a plant ⟨~ tubers⟩ (2) : growing from the base of a stem, from a rootlike stem, or from a stem that does not rise above the ground ⟨~ leaves⟩ b : of, relating to, or constituting a linguistic root c : of or relating to a mathematical root d : designed to remove the root of a disease or all diseased tissue ⟨~ surgery⟩ 2 : of or relating to the origin : FUNDAMENTAL 3 a : marked by a considerable departure from the usual or traditional : EXTREME b : tending or disposed to make extreme changes in existing views, habits, conditions, or institutions c : of, relating to, or constituting a political group associated with views, practices, and policies of extreme change d : advocating extreme measures to retain or restore a political state of affairs ⟨the ~ right⟩ — **rad-i-cal-ness** *n*

²radical *n* (1641) 1 a : a root part b : a basic principle : FOUNDATION 2 a : ROOT 6 b : a sound or letter belonging to a radical 3 : one who is radical 4 : FREE RADICAL; *also* : a group of atoms bonded together that is considered an entity in various kinds of reactions 5 a : a mathematical expression indicating a root by means of a radical sign b : RADICAL SIGN

radical chic *n* (1970) : a fashionable practice among socially prominent people of associating with radicals or members of minority groups

rad-i-cal-ism \'rad-i-kə-,liz-əm\ *n* (1820) 1 : the quality or state of being radical 2 : the doctrines or principles of radicals

rad-i-cal-ize \-kə-,liz\ *vt* **-ized; -iz-ing** (1823) : to make radical esp. in politics — **rad-i-cal-iza-tion** \,rad-i-kə-lə-'zā-shən\ *n*

rad-i-cal-ly \'rad-i-k(ə-)lē\ *adv* (1609) 1 : in origin or essence 2 : in a radical or extreme manner

radical sign *n* (1668) : the sign √ placed before an expression to denote that the square root is to be extracted or that some other root is to be extracted when a corresponding index is placed over the sign

rad-i-cand \,rad-ə-'kand\ *n* [L *radicandum*, neut. of *radicandus*, gerundive of *radicari*] (1900) : the quantity under a radical sign